“EFFECTS OF PLYOMETRIC AND CORE STABILITY EXERCISE ON PHYSICAL PERFORMANCE OF BADMINTON PLAYERS”

- A COMPARATIVE STUDY

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A DISSERTATION SUBMITTED TO THE TAMILNADU
Dr. M.G.R MEDICALUNIVERSITY, CHENNAI,

AS PARTIAL FULFILLMENT OF THE

MASTER OF PHYSIOTHERAPY DEGREE

MAY 2019

CERTIFICATE

Certified that this is the bonafide work of **Miss. D.Pooja** of K.G. College of Physiotherapy, Coimbatore submitted in partial fulfilment of the requirements for the Master of Physiotherapy Degree course from the Tamil Nadu Dr.M.G.R. Medical University under the **Registration No:271750141** for the MAY 2019 Examination.

Place:

Date: Principal

A Dissertation on

"EFFECTS OF PLYOMETRIC AND CORE STABILITY EXERCISE ON PHYSICAL PERFORMANCE OF BADMINTON PLAYERS"

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Has been submitted in partial fulfillment for the requirement of the Master of Physiotherapy degree,

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Internal Examiner **External Examiner**

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- A COMPARATIVE STUDY

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I. INTRODUCTION

Badminton is one of the most popular sports played all around the world. It is a racket sport that is either played by individuals or a team of two opposing each other against a divided net to score point. It was developed from a childhood game called battledore and shuttlecock. Badminton was called "Poona" in India in 18^{th} century. The Duke of Beaufort launched Badminton officially in 1873.Badminton House in Gloucestershire is the base for International Badminton Federation 1934.

Badminton players need to conduct various patters of movements during the game which includes specialized twists, jumps, footwork, swings to strike the shuttlecock and keep it moving back and forth on the court. Thus, the game is characterized by a changing temporal structure with actions of short period and high or medium intensity coupled with a short resting time.

Badminton players need to be quick and agile around the court. Muscle strength, muscular endurance, power, speed, agility, flexibility, balance and coordination are the important components for a player.

Badminton requires a specific physical conditioning in terms of motor and action controls; coordinative variables such as reaction time, foot stepping and static or dynamic balance, which are essential motor demand in this sport. (M.Phomsoupha et al., 2015). Badminton is a very explosive sport, involving unique movement techniques and relatively small field strength supported by physical condition, mental attitude, courage, intelligence and technical skills of players as well as tactical efficiency (Heang et al., 2006)

Agility is classically been defined as simply the ability to change direction rapidly (Elliot et al., 1994) but also as the ability to change direction rapidly and accurately (Barrow et al.,1971).

Agility is one of the important components in badminton. Agility is needed to maintain balance when performing maneuvers quickly and accurately. Agility in badminton is associated with the ability of the athlete to move and move around in maintaining the position of the shuttlecock, so there is a need for accuracy and speed of reaction in changing direction, changing direction quickly requires leg muscle power, which exercises involving rapid jumps are able to stimulate muscle to increase power (Vaczi et al., 2011)

Agility includes whole body change of direction as well as rapid movement and direction change of limbs (Lancaster et al., 1985). A multi-planar or multi directional skill that combines acceleration, explosiveness, and reactiveness (Moreno et al., 1995)

Balance is an ability to maintain a base of support with minimal movement action and dynamically to perform a motor task while maintaining a stable position. Indeed, balance is the ability to maintain dynamic integration of interior and exterior forces during motor action tasks (J.C Yomker et al., 2007)

Balance is usually considered a static process and in fact is a comprehensive, dynamic three-dimensional process contains multiple neural pathways. Badminton is a dynamic equilibrium process which involves loss of balance after landing. Thus players need body coordination and dynamic balance (M.Kong et al., 2017)

In this changing scenario, fitness training and injury prevention, programs incorporating spinal muscular training, including core strengthening and stability exercises have become popular because the core is considered to be the anatomical and functional (Haapasalo et al., 2007)

During performance of sports skills, a stable core provides a foundation upon which the muscle of the upper and lower extremities can accelerate body segments and transfer force between distal and proximal body segments (Samson et al., 2007). Previously Core stability exercises were widely used for the prevention and rehabilitation of injuries of the lower back and lower extremities. (Willardson et al., 2007) Recently core stability training has been purported to enhance athletic performance, but the literature has not supported these and, in fact reported a small effect on performance (Mokha et al., 2008). However the use of core stability exercises improves dynamic postural control (Aggarwal et al., 2010)

The core musculature includes muscles of the trunk and pelvis that are responsible for maintaining the stability of the spine and pelvis and are critical for the transfer of energy from larger torso to smaller extremities during many sport activities (McManus AM et al., 2005) Thus it is theoretically believed that if the extremities are strong and the core is weak the decrease in muscular summation through the core will result in less force production and inefficient movement patterns. The core stability in athletics dynamically control and transfer large force from the upper and lower extremities through the core in order to maximize the performance and promote efficient biomechanics (Hibbs et al., 2008)

Plyometric exercise has been used in all area of sport to increase muscle strength and explosive power. Plyometric exercises consist of eccentric movements which are then followed by concentric contraction in the same muscle group. Muscle strength training can contribute to increase acceleration, strength and limb power (Vaczi et al., 2011)

Plyometric exercise program involves repetitive jumping, running, and explosively altering motion. These movements are the components that can help in improving agility because it exploits the adaptation of stretch shortening cycle through the neuromuscular system in helping to increase leg muscles power so agility improvement can be achieved. Plyometric training techniques are used by athletes in all types of sports to increase strength and explosiveness (Chu et al., 1998).

Plyometric consists of a rapid stretching of a muscle immediately followed by a concentric or shortening action of the same muscle and connective tissue (Earle et al., 2000). The muscles capability of generating high force is dependent on its contractile history and can be acutely enhanced following voluntary contraction at maximal or near maximal intensities (Bishop D et al., 2009)

Shuttle run test measures agility and speed while running between two lines 10m apart to pick up small blocks. It tests the speed, body control and the ability to change direction. The participant sprints to the opposite line and then picks up a block runs back and places it on the starting line. Then turning without a rest they run back to collect the next block. The time taken to complete the two rounds is recorded.

Illinois agility test the individual starts by lying face down by the first cone. Staring at cone 1 he is required to run to cone 2 which is placed at a distance of 10meters away from the first. He then runs 10 meters to cone 3. At this point the individual has to weave around cones 3,4,5,6. After this he has to go through 5,4,3 he will then run to cone 8. Then the time taken to complete the task is recorded.

Y Balance test is a simple yet reliable test used to measure dynamic balance. The athlete is asked to balance on one leg whilst simultaneously reach as far as possible with the other leg in three separate directions: anterior, posterolateral and posteromedial. Therefore the test measures the athlete strength, stability and balance in various directions. The Y balance test score is calculated by summing the 3 reach direction and normalizing the results to the lower limb reach.

1.1 NEED FOR THE STUDY

Agility and balance are the main components for the enhancement of physical performance and for preventing injury in badminton players.

The main purpose of the study is to compare the effect of plyometric and core stability on agility and balance in badminton players.

Plyometric and core stability plays an important role in improving the level of fitness in badminton players.

Most of the studies suggest that there is improvement in agility and balance in players who underwent plyometric and core stability training programme. There are not much studies comparing the effect of both plyometric and core stability training.

This study is to find out the improvement of agility and balance on plyometric and core stability and also to compare the training with the physical performance.

1.2 AIM:

To find out the effect of plyometric versus core stability exercises on agility and balance in badminton players

1.3 OBJECTIVES:

To find out the effect of plyometric on agility and balance in badminton players

To find the effect of core stability exercises on agility and balance in badminton players

To compare the effect of plyometric and core stability exercises on agility and balance in badminton players

1.4 KEY WORDS:

Agility

Balance

Core stability exercises

1.5 HYPOTHESIS

NULL HYPOTHESIS:

There is no significant difference between plyometric and core stability exercises for agility and balance in badminton players.

There is a significant difference between plyometric versus core stability exercises for agility and balance in female badminton players

ALTERNATE HYPOTHESIS:

There is a significant difference between plyometric and core stability exercises for agility and balance in female badminton players.

There is a significant difference between plyometric versus core stability exercises for agility and balance in female badminton players

II REVIEW OF LITERATURE

MICHAEL PHOMSOUPHA et al., 2015

Badminton is one of the most popular sports in the world with a highly demanding with an average of 90% of the players maximum heart beat, 60 – 70% of aerobic system and approximately 30% of anaerobic system, with greater demand on the alactic metabolism with respect to lactic anaerobic metabolism.

P. CINTHUJA et al., 2015

Explosive power of lower limbs, upper body strength and endurance in females increased with level of performance while in males the explosive power of lower limbs, upper body power, agility, and speed increased with level of performance but aerobic endurance decreased. Duration of training sessions was significantly related to flexibility of shoulder, agility in female and upper body strength and endurance in male players. Speed, endurance and upper body strength were increased with duration of practice session.

JANUSZ JAWORSKI et al., 2016

Initial stage of training process, sports skill level is determined by a comprehensive fitness. At the next stage, it largely depends on body size and efficiency of moving on the court and a wide set of variables that determine movement coordination. In the group of juniors, this level is more determined by maximal anaerobic power of the upper limbs, wrist mobility and a complex of coordination abilities with higher degree of motor organization

KIBLER et al., 2006

Suggested that core stability as the control of the position and motion of trunk over the pelvis which allows optimum production of motion over the terminal segment in integrated kinetic chain activities, this stabilizes the spine mechanics and delivers shear force to the lower segment which in turn improves agility for the players. While applying core stability exercises the length dependent pattern occurs in the muscle, which increases stability around one joint, and are mediated by gamma afferent input and involve reciprocal inhibition of muscle to provide stiffness around a joint. Force dependent pattern integrate activation of multiple muscle to move several joints and develop force, and are mediated by Golgi tendon receptors. Core stability training integrates activation of multiple segments which provides force generation leads into strong proximal stability and distal mobility. Higher core stability performance leads to improve synchronization of motor units and lower of neural inhibitory reflexes, so that these training provides better control of the intersegmental motion of the spine. As a result the immediate response of action in lower extremities was improved.

BIPASA SETH et al., 2016

Badminton game performance was significantly related to coordinative abilities. Selected coordinative abilities in this study versus side step jump, dynamic balance, hand reaction, foot reaction were significantly related to badminton game performance. Significant relationship was found between badminton game performance and the badminton strokes variable. Selected technique variable in this study versus short service, long service, forehand clear and backhand clear strokes were significantly related to badminton game performance.

MEHMET FATIH YUKSEL et al., 2015

Racket sports such as table tennis, tennis, badminton and squash require a combination of psychological stability, tactical analysis, motor coordination as well as strong physical and physiological attributes. These demands make the sports particularly challenging for athletes at different levels. According to the results of the study, eight weeks of badminton training improves balance performance of pubertal children. Apart from the close relationship between balance skills and children’s motor performance, a dysfunction in postural control may be used as a sign of several types of developmental deficits.

TARIK OZMEN et al., 2016

Core strength training on core endurance, dynamic balance and agility in adolescent badminton players were evaluated with Star Excursion Balance Test, Illinois Agility Test, and the core endurance tests. There were significant increases in directions of Star Excursion Balance Test and core endurance tests. The Core strength training resulted in significant gains in directions of the Star Excursion Balance Test and core endurances in adolescent badminton players.

IBRAHIM HAMED et al., 2017

Core training two times per week for six weeks as relatively the period of training in current study provided an improvements in trunk flexor, extensor endurance and right lateral endurance. 6 weeks core strength training resulted in an improvement at the total reached distance of the dynamic Balance Star Excursion Balance Test in adolescent badminton players, who participated in training programme, 6 core exercises for three sessions per week. The core endurance test scores of adolescent badminton players showed highly significant at post-training when compared to the pre-training.

HASSAN SADEGHI et al., 2013

The core is comprised of the lumbo-pelvic-hip complex and is activated first prior to gross body movements. Core stability can improve strength of hip and trunk muscle which is important to increase dynamic balance in volleyball players.

Dynamic balance is influenced by core exercises and was measured in this study using SEBT, which showed increase in direction.

URS GRANACHER et al., 2012

Nine weeks of progressive core instability strength training resulted in significant improvement in muscle strength of the trunk flexors, extensors, rotators and lateral flexors, a significantly enhanced spinal mobility, and significant improvement in dynamic balance (stride velocity) and functional mobility (Time Up &Go test). It proved the feasibility and effectiveness of a progressive Core Instability Strength Test on measures of trunk muscle strength, spinal mobility, dynamic balance and functional mobility in healthy older adults.

NICOLE L. KAHLE et al., 2009

Dynamic balance is a key component of injury prevention and rehabilitation in sports. Training the core muscles has been hypothesized as an intervention for improving balance. The effects of a core stability program on dynamic balance as measured with the Star Excursion Balance Test before and after a 6-week intervention period. During the 6-week period, the exercise group performed a core stability program, whereas the control group refrained from any new exercise. Maximum excursion distances improved for the exercise group, compared with the control group. This result justifies the hypothesis that core strengthening can improve dynamic postural control during treatment and rehabilitation of athletic injury.

MICHELLE A. SANDREY et al., 2013

The 6-week core-stabilization-training program designed to benefit track and field athletes resulted in significant improvements in medial and antero-medial reach directions and core endurance. Meaningful clinical improvement pretraining to post training was evident. Furthermore, progression based on exercise difficulty is certainly one possible way for any type of track and field athlete to use supplemental strength training and dynamic movements in unstable environments with added resistance to optimize dynamic-postural stability and core endurance.

SAMSON et al., 2007

Tennis is a sport that involves multidirectional movement patterns that challenge the ability to maintain dynamic stability. Tennis players need a stable core to effectively perform upper and lower extremity movements. The core stabilization program emphasizes on the eccentric and isometric muscle actions that are believed to enhance dynamic postural control. Five-week training study program produced positive effects on dynamic postural control, and that continuation of the program for a longer period of time will provide further benefit during performance of sports skills. A stable core provides a foundation upon which the muscle of upper and lower extremities can accelerate body segments and transfer force between distal and proximal body segments.

BASHIR et al., 2018

The effect of core training on dynamic balance and agility among junior athletes plays an important role. Core training can be incorporated safely with players who train regularly to improve their dynamic balance and agility, which can lead to better performance.

JOHN HILL et al., 2011

Core stability and plyometric training have become common elements of training programs in competitive athletes. Core stability allows stabilization of the spine and trunk of the body in order to allow maximal translation of force to the extremities. Plyometric training is more dynamic and involves explosive-strength training. Integration of these exercises theoretically begins with core stabilization using more static exercises, allowing safe and effective transition to plyometric exercises. Both core strengthening and plyometric training have demonstrated mixed but generally positive results on injury prevention and rehabilitation of certain type of injuries.

TAMARA C. VALOVICH MCLEOD et al., 2009

Agility training, balance and proprioception, plyometric, and functional strengthening were able to improve the static and dynamic balance, as measured with balance tests. Balance improvements and possible performance enhancement through participation in a neuromuscular-training program may increase athlete compliance, which may afford them the benefits of these programs as a means of injury prevention.

JOHN SHAJI ET AL., 2009

Dynamic stretching is a useful addition to plyometric for the athletes who require repetitive jumping activity and agility. Dynamic stretching, or passive continuous motion, is effective for decreasing passive muscle stiffness. Dynamic stretching may decrease muscle stiffness by breaking the stable bonds between actin and myosin filaments or by increasing muscle temperature. Movement without holding at end range of motion, may not reduce neuromuscular sensitivity, but help to enhance coordination and proprioceptive sensation. Plyometric training is more effective in improving vertical jump performance in the stretch shortening cycle jumps, as it enhances the ability of subjects to use the elastic and neural benefits of the stretch shortening cycle. There was overall improvement in agility score which received plyometric training program is consistent with the result of a study of 6 weeks of plyometric training on agility.

RODRIGO RAMIREZ-CAMPILLO et al., 2015

Unilateral, bilateral, and combined unilateral & bilateral plyometric were used in young soccer players. Plyometric groups show a statistically significant increase in performance, with a small-to-moderate to increased strength and power of legs' extensor muscles and these changes could be attributed solely to neuromuscular adaptations. It may be that these neuromuscular and strength-power adaptations had an effect on the biomechanical factors related to kicking performance, such as maximum linear velocity of the toe, ankle, knee, and hip at ball contact, which may have cumulatively or individually contributed to a higher ball kicking velocity.

GREGORY D. MYER et al., 2006

Plyometric and Balance training are effective at increasing measures of lower extremity neuromuscular power and control as well as decreasing leg dominance. However, the balance component may be more important to improve single limb force attenuation strategies. A combination of Plyometric and Balance training may further maximize the effectiveness of preseason training for female athletes.

MAAMER SLIMANI et al., 2016

8 weeks of systematic application of Plyometric are necessary to improve physical performance in elite players. This review also shows that short Plyometric

Training (<8 weeks) has the potential to enhance a wide range of athletic performance (i.e. jumping, sprinting and agility) in children and youth amateur players. Short-term Plyometric on non-rigid surfaces (i.e. aquatic, grass or sand-based Plyometric Training) could elicit similar increases in jumping, agility and sprinting performance as traditional Plyometric Training. Thus, the present review indicates a greater effect of Plyometric Training alone on jump and sprint (30 m sprint performance only) performances than the combination of Plyometric Training with sprint/strength training.

LIM JOE HEANG et al., 2012

Plyometric training programme is able to improve agility over duration of 6-weeks in badminton players. Technical training, pattern running and reactive training can improve agility. Badminton training programme emphasizes performing the correct movements, performing acceleration, decelerations and sharp changes of direction can be used as a training strategy in other sports as well.

M. FROHLICH et al., 2014

Plyometric training applied improved jump power or jump height, while its influence on the technical component of the forehand overhead smash in the sense of a spatiotemporal improvement is rather negligible. This would mean that the influence of the optimal technique applied to the forehand overhead smash in the sense of a suitable combination of sub-segments outweighs pure jump force improvement. Additional plyometric training can positively influence the performance of junior athletes of badminton squad in terms of various jump parameters, such as squat jump and drop jump.

RAOUF HAMMAMI et al., 2016

Sequencing four weeks of balance training prior to four weeks of plyometric training in 12-13 year old male elite soccer players resulted in superior performance enhancements compared to plyometric prior to balance training. Plyometric provided significantly greater improvements in the reactive strength index, absolute and relative leg stiffness, and a trend for the Y balance test. Sprinting, change of direction, agility and jumping among other power related activities additionally improved, during the subsequent 4 weeks of balance training.

KARIN VASSIL et al., 2011

Squat, plyometric and squat & plyometric showed that the squat group increased 3.30 cm in vertical jump, the plyometric group increased 3.81 cm and the squat-plyometric group increased 10.67 cm along with an increase in vertical jump the speed force also tend to increase thus results indicate that combined training can be more effective than plyometric training alone. Plyometric exercises are effective tools for improving young volleyball player's ability to perform repeated maximal jumps at the maximum height

S. RAMESHKANNAN et al., 2014

8-weeks of plyometric on agility of male handball players, Plyometric training show improved performance in agility tests either because of better motor recruitment or neural adaptations. Plyometric training, when used with a periodized strength-training program, can contribute to improvements in vertical jump performance, acceleration, leg strength, muscular power, increased joint awareness, and overall proprioception

HAMID ARAZI et al., 2011

The combined resistance and sprint/plyometric training can be the reason of sprint improvement, by facilitates the neuromuscular system into making a more rapid transition from eccentric to concentric contraction. Biomechanical analyses of sprinting have shown that sprints greater than 50 m may depend upon elasticity of the plantar flexor muscles to a greater extent than do shorter sprints, which consist mostly of acceleration. Sprints of at least 100 m consist of 3 phases: acceleration, constant velocity (or maximum speed), and deceleration. The acceleration phase is highly dependent upon reaction time and the athlete's ability to generate force and power during propulsion

SELVAM RAMACHANDRAN et al., 2014

The short term two weeks plyometric training program combined with dynamic stretching program shows statistically significant improvements in vertical jump height and agility and no changes in muscle girth and isometric muscle strength. Dynamic stretching protocol was used and is also reported to have improvements in agility and sport performance and helped to prevent injuries associated with short term plyometric training

VICENTE-RODRIGUEZ et al., 2011

Interrater reliability and criterion-related validity 10-m shuttle run indicated that manual measurements by a trained rater, using a stopwatch, seem to be a valid method to assess speed and agility fitness testing in adolescents.

ROBERT G. LOCKIE et al., 2014

Field-sport athletes who are faster over 10 m exhibit greater leg power and relative strength, while absolute leg strength and power, and performance in a 10-m sprint and T test (a test involving linear sprinting, lateral shuffling, and backward running) in male basketball players. Thus the change of-direction-speed branch of the model in that both leg strength and leg power contribute to planned agility

DIMAS SONDANG IRAWAN et al., 2017

Agility can be achieved by improving balance and strength of lower limb. Plyometric exercise can increase power of lower extremity. A gradual, progressive, and measurable exercise improves athlete performance and reduces risk of injury..

Agility performance was measured by Illinois Agility Test.6 Weeks Progressive Plyometric Training improves overall agility in badminton players and could become training design to improve skills

LTC SCOTT W et al., 2013

Y-Balance Test is reliable in obtaining screening setting by multiple raters across a 48-hour period. Y- Balance Test scores shows good reliability, measurement stability was improved when averaging 3 trials. Considering that 6 practice trials and 3 test trials are recommended to reduce a learning effect on the Y- Balance Test

PAUL P. GORMAN et al., 2012

Y- Balance Test is reliable between sessions and between raters. Additional analyses revealed no gender or bilateral differences for any of the normalized reach directions or the composite scores in this limited sample. Y- Balance Test is an appropriate tool to be used as a clinical measurement of balance performance.

GARRETT F. COUGHLAN et al., 2012

A difference in reach-direction distance was observed between theStar Excursion Balance Test and Y- Balance Test, with no differences noted in the posteromedial and posterolateral directions. Postural-control strategies used in completing the tests appear to influence reach performance. It is applicable for implications of both researchers and clinicians in interpreting and implementing these dynamic balance tests. Reach values and research established for the Star Excursion Balance Test in athletic, healthy, and injured populations may not be transferrable to Y-Balance Test performance. We are also the first to report on such values for the Y-Balance Test in a healthy athletic male group.

MICHELE A. RAYA et al., 2013

The moderate correlation between the T-Test, and Illinois Agility Test was expected because all three tests measure the construct of agility with components such as balance, posture, coordination, power, and speed. The Illinois Agility Test assess multiplanar agility by assessing how quickly an individual is able to complete a course consisting of a prone to standing transfer, multiple forward movements, three 180° turns, and forward weaving through stationary cones over a 60 m course.

YOUNES HACHANA et al., 2013

Measurement of speed, to a large extent, may differentiate the variance in agility and leg power (jump height) profiles between male team sport athletes in our study. The Illinois Agility Test is a reliable test for assessing speed in male team sport athletes. Its performance is independent of acceleration and power of the legs but significantly related to speed.

III. METHODOLOGY

3.1 STUDY DESIGN:

Pre test and post test experimental study design

3.2 STUDY SETTING:

The study was conducted at the Therapeutic Gymnasium K.G Campus, Saravanampatti, Coimbatore.

3.3 STUDY DURATION:

Study duration was 6 weeks.

3.4 SAMPLING TECHNIQUE:

The sample size was determined based on a pilot study 10 participants were divided randomly into two equal parts, and the main part of the study was conducted on them. The mean and SD for the parameters for his pilot study with α= 0.05 and 90% power were used to calculate the sample size of N=30.

A total of about 30 recreational badminton players who fulfilled inclusive and exclusive criteria were selected by simple random sampling method, out of them 15 were allotted in Group A and 15 in Group B.

3.5 CRITERIA FOR SELECTION OF SUBJECTS:

INCLUSION CRITERIA:

- Active recreational badminton players
- Age group 18 – 25 years
- Both male and female players were selected
- Body mass index of players was between 18-24
- Playing badminton for more than 1 year were selected
- Players who play badminton for 4 days per week
- Not involved in any formal abdominal/ core training program or plyometric training program.

EXCLUSION CRITERIA:

- Who had low back pain during last 1 month
- Participation in any formal core training and balance training program
- Having lower limb fracture in the last four months
- Any chronic ligament sprain.
- Trauma to lower limb and any neurological disorder having balance impairment
- Not willing to participate in the study

3.6 OUTCOME PARAMETER:

AGILITY

- Shuttle run
- Illinois agility test

BALANCE

- Y- Balance test

3.7 OPERATIONAL TOOLS:

- Stop watch
- Cones
- Tape
- Swiss ball
- 1 KG Medicine Ball

3.8 VARIABLES:

INDEPENDENT VARIABLE:

- Plyometric
- Core stability exercises

DEPENDENT VARIABLE:

- Agility
- Balance

3.9 ORIENTATION OF THE SUBJECT:

Before the study was conducted, all the participants have read and signed a consent form which informed them about the study procedure, their rights and contradiction of the study. There were asked to inform if they feel any discomfort during the study.

Each player was asked to complete a questionnaire outlining any history of injury and activity level prior to participating in preseason training.

3.10 PROCEDURE:

30 subjects were recruited for this study and were divided into two groups of 15 members each using random sampling. They underwent different training program. Prior to the training session the players were subjected pretest evaluation of agility and balance using 10meters shuttle run, Illinois agility test and Y-Balance test(Appendix – III, IV & V)

GROUP A:

Players under this group underwent normal warm up and stretching before entering into the training session.

Training	Plyomeric drills	Set* Reps	Intensity
Week 1:			
	Side to side ankle hops	2 * 15	Low
	Standing jump and reach	2*15	Low
	Front cone hops	5*6	Low
Week 2:			
	Side to side ankle hops	2*15	Low
	Standing jump	5*6	Medium
	Lateral jump over barrier	2*15	Medium

	Double legs hops	5*6	Medium
Week 3			
	Side to side ankle hops	2*12	Low
	Standing jump	5*6	Low
	Lateral jump over barrier	2*12	Medium
	Double legs hops	3*8	Medium
	Lateral cone hops	2*12	Medium
Week 4:			
	Diagonal cone hops	4*8	Low
	Standing long with lateral sprint	4*7	Low
	Lateral cone hops	2*12	Medium
	Single leg bounding	4*7	High
	Lateral jump single leg	4*6	High
Week 5:			
	Diagonal cone hops	2*7	Low
	Standing long with lateral sprint	4*7	Medium
	Lateral cone hops	4*7	Medium
	Cone hops with 180degree turn	4*7	Medium
	Single leg bounding	4*7	High

	Lateral jump single leg	2*7	High
Week 6:			
	Diagonal cone hops	2*12	Low
	Hexagonal drill	2*12	Low
	Cone hops with change of direction sprint	4*6	Medium
	Double leg hops	3*8	Medium
	Lateral jump single leg	4*6	High

GROUP – B

Randomly selected players underwent warm up and stretching prior to the training session.

Core strengthening exercises concentrated mainly on transverse abdominus (TrA) and multifidus (MF) muscles.

TRAINING	CORE STRENGTHENING EXERCISE	SETS*REPS
Week 1 & 2:		
1.	**TrA& MF muscle contraction:**	
	Crook supine lying position	3*15

	Prone lying position	3*15
	Quadruped position	3*15
	Standing on single limb	1*10
	Crook lying with leg movements	2*10
2.	Bridging	3*15
3.	Quadruped exercise with foot and hand lifts	3*15
4.	Wall squarts	3*15
5.	Seated medicine ball rotation	3*15
Week 3 & 4		
	TrA& MF contraction	
	Cycling	3 *15
	Seated on swiss ball	3 *15
	Multidirectional lunges	2*10
	Squarts with swiss ball	3 *15
	Superman	2*10
Week 5		
Planks	Modified planks	3 *10
	Front planks	3*10
	Side planks	3*10

	TrA& MF contraction :	
	Diagonal curls on swiss ball	3 *15
	Twist on swiss ball	3*15
Week 6:		
Stability ball:	Front Planks	2*10
	Back bridge	2*10
	Theraband resisted shoulder movements seated	3*15
	Prone hip-knee flex – ext	2*10
	Twist on swiss ball with 1 Kg medicine ball	10 reps
	Stability trainer standing twists with 1 Kg medicine ball	3*15

3.11 STATISTICAL TOOLS:

Statistical analysis was done by using student'tʼ test. Paired'tʼ test was used to find out the improvement within the group. Unpaired'tʼ test was used to find out the difference between two groups.

Formula of paired 'tʼ test: the paired t-test was used to compare the Pre and Post test values of Group A and Group B.

$$S=\sqrt{\frac{\sum d^2 - \frac{\sum d^2}{n}}{n-1}}$$

$$t=\frac{\bar{d}\sqrt{n}}{s}$$

where,

d = difference between the pre-test versus post test

$\bar{d}$ = mean difference

n = total number of subjects

s = standard deviation

$\sum d^2$ = sum of the squared deviation

Formula of unpaired't' test:

The unpaired 't' test was used to explore between Group A and Group B.

$$S = \sqrt{\frac{\sum(x_{1-}\overline{x_2})^2 + (x_2-\bar{x}_2)^2}{n_{1+}n_2-2}}$$

$$T = \frac{\overline{x_1}-\overline{x_2}}{S}\sqrt{\frac{n_1 n_2}{n_1+n_2}}$$

Where,

n_1 = total number of subjects in Group A

n_2 = total number of subjects in Group B

x_1 =difference between pre-test versus post-test of Group A

$\overline{x_1}$ =mean of Group A

$x\ _2$=difference between pre-test versus post-test of Group B

$\overline{x_2}$ = mean of Group B

S = Standard deviation

IV. DATA ANALYSIS AND INTERPRETATIONS

Baseline treatment and post experimental treatment values of pain and physical performance were subjected to statistical analysis.

Paired ‘t’ test were used to assess the difference between pre treatment and post treatment in both the group.

Independent ‘t’ test were used to assess difference between post treatment measures of all the group including control group to evaluate any difference in the effectiveness of treatment.

TABLE – I

PRE TEST AND POST TEST VALUES OF

10M- SHUTTLE RUN

GROUP A – PLYOMETRICS

S.NO	GROUP – A	MEAN	STANDARD DEVIATION	‘t’ VALUES
1.	Pre test	3.59	0.61	10.19
2.	Post test	2.79	0.6	

The table shows the test value of Group A is 10.19 which was greater than the tabulated ‘t’ value 2.145. The result shows that there were marked difference between pre test and post test values.

GRAPH – I

PRE TEST AND POST TEST VALUES OF

10M – SHUTTLE RUN

GROUP A – PLYOMETRICS

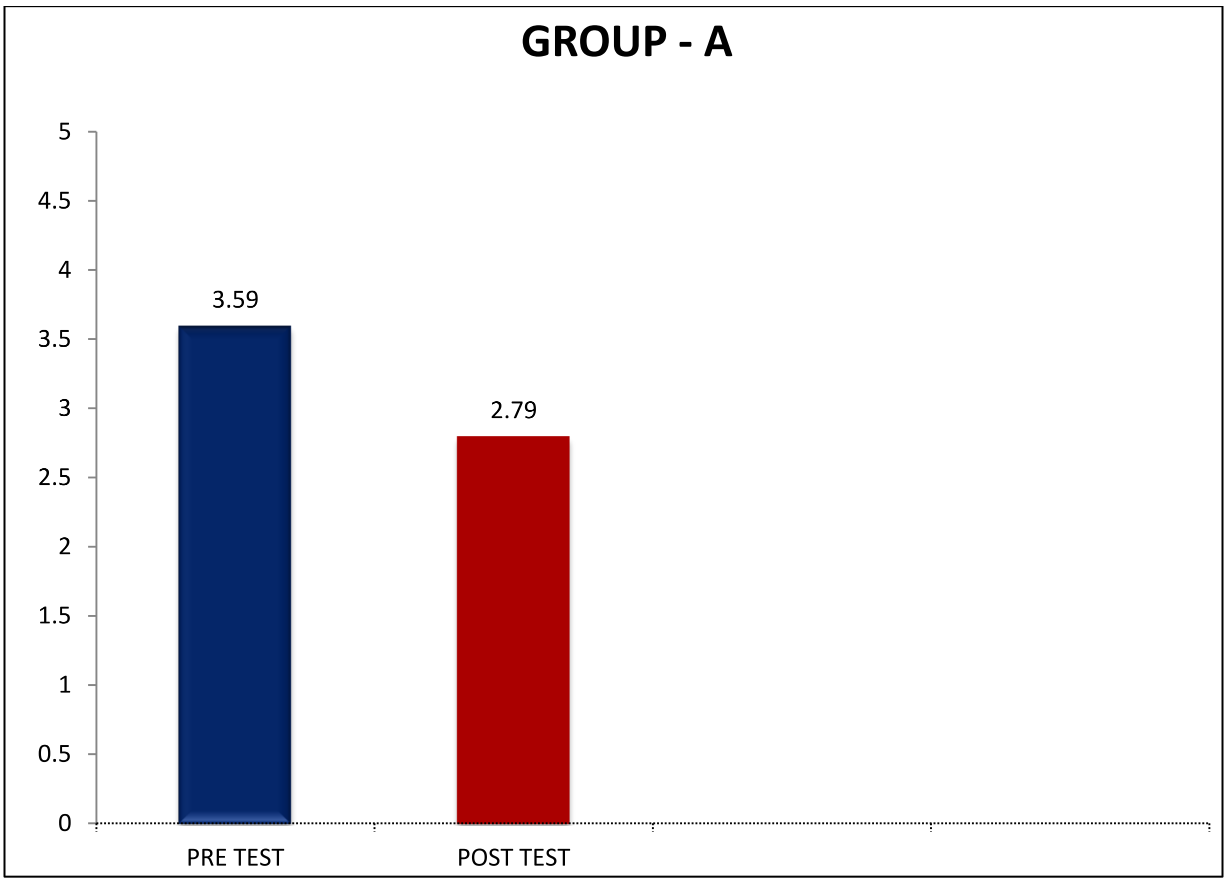


TABLE – II

PRE TEST AND POST TEST VALUES OF

10 M- SHUTTLE RUN

GROUP B –CORE STABILITY

S.NO	GROUP - A	MEAN	STANDARD DEVIATION	‘t’ VALUES
1.	Pre test	3.22	0.62	11.02
2.	Post test	1.85	0.51	

The table shows the test value of Group B is 11.02 which was greater than the tabulated ‘t’ value 2.145. The result shows that there were marked difference between pre test and post test.

GRAPH – II

PRE TEST AND POST TEST VALUES OF

10M – SHUTTLE RUN

GROUP B CORE STABILITY

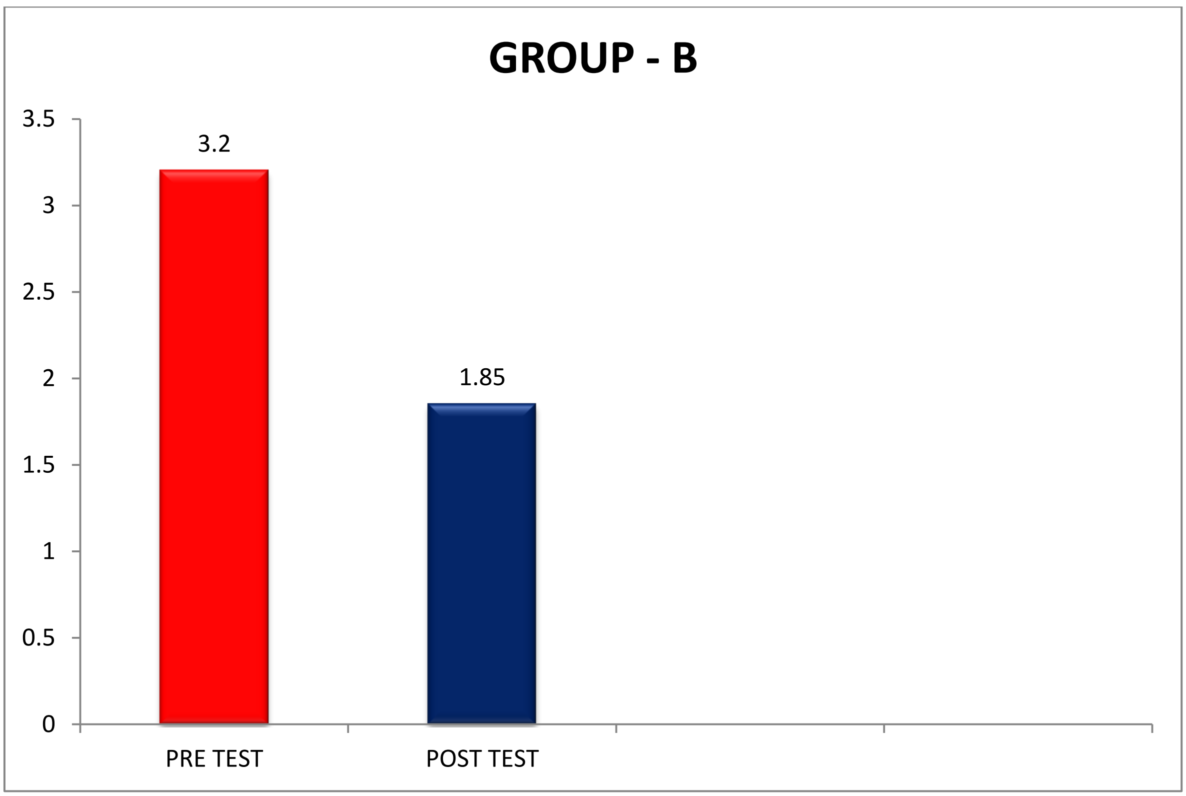


TABLE – III

UNPAIRED 'T' TEST VALUES

GROUP A & GROUP B

S.NO	POST TEST	MEAN	STANDARD DEVIATION	't' VALUES
1.	GROUP-A	2.79	0.6	4.66
2.	GROUP-B	1.85	0.51	

The table shows the test value of Group A and Group B is 4.66 which was greater than the tabulated 't' value 2.048. The result shows that there were marked difference between Group A and Group B.

GRAPH – III

UNPAIRED 'T' TEST VALUE

GROUP A & GROUP B

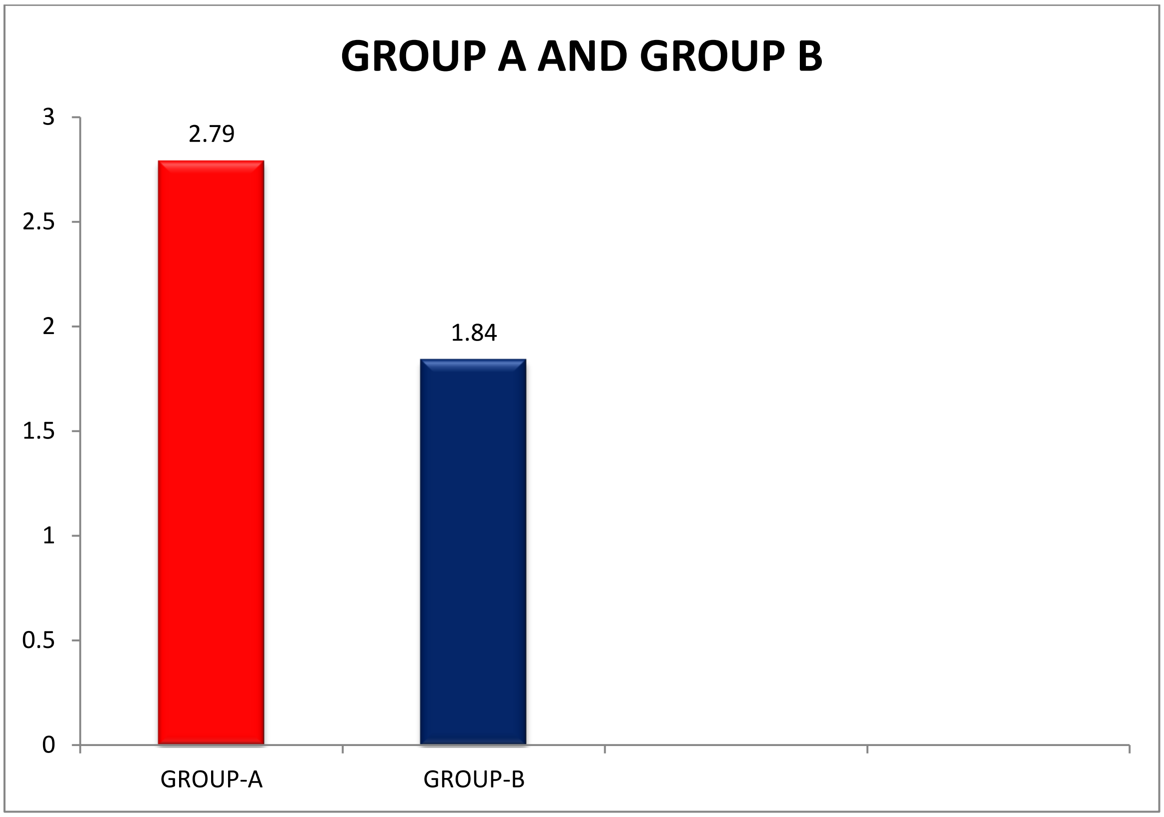


TABLE – IV

PRE TEST AND POST TEST VALUES OF

ILLINOIS TEST

GROUP A – PYLOMETRICS

S.NO	GROUP - A	MEAN	STANDARD DEVIATION	't' VALUES
1.	PRE-TEST	23.83	2.06	8.71
2.	POST-TEST	20.37	2.5	

The table shows the test value of Group A is 8.71 which was greater than the tabulated 't' value 2.145. The result shows that there was marked difference between pretest and post test values.

GRAPH – IV

PRE TEST AND POST TEST VALUES OF

ILLINOIS TEST

GROUP A – PLYOMETRIC

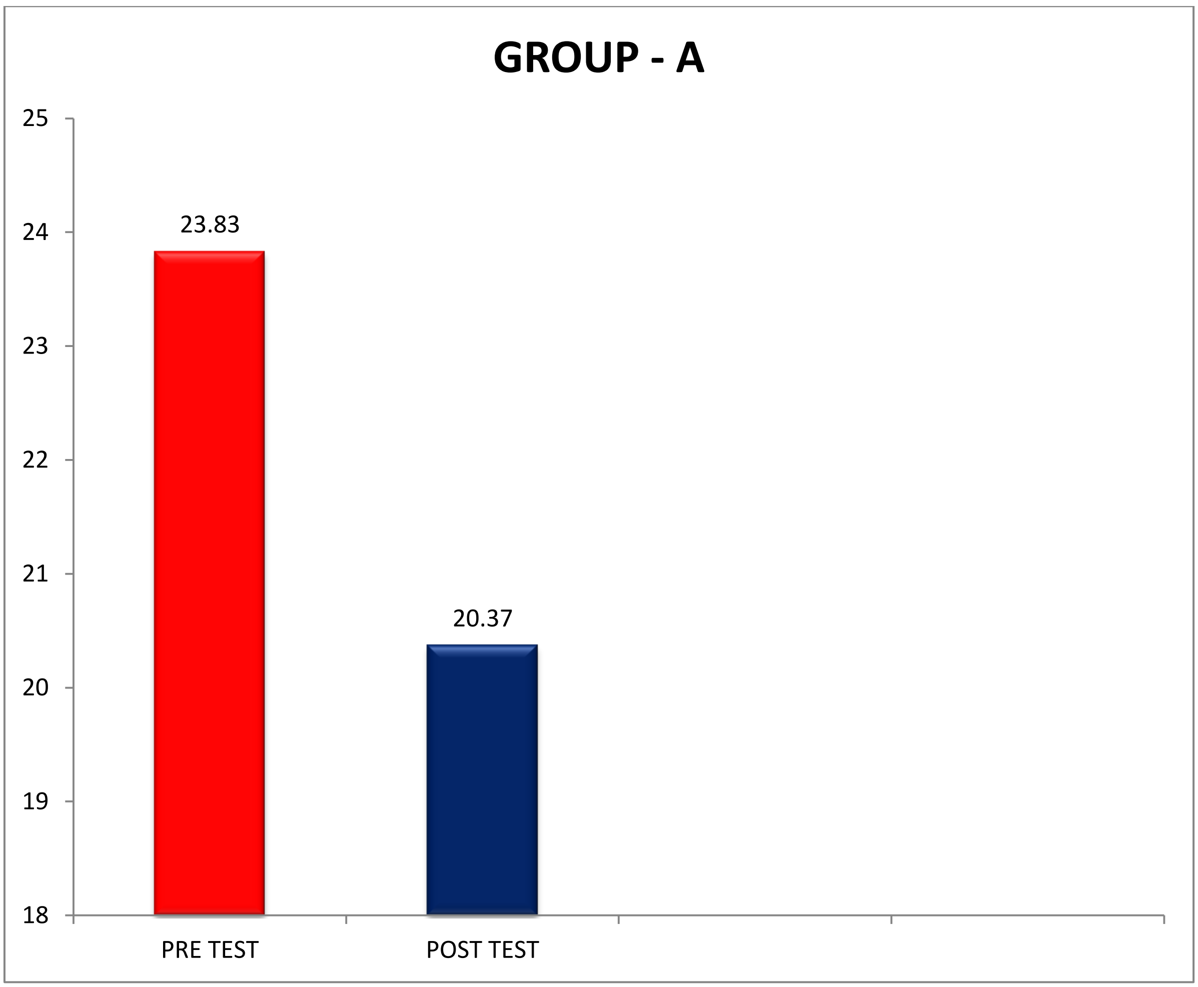


TABLE – V

PRE TEST AND POST TEST VALUES OF

ILLINOIS TEST

GROUP B- CORE STABILITY

S.NO	GROUP - A	MEAN	STANDARD DEVIATION	‘t’ VALUES
1.	PRE-TEST	24.3	2.4	6.9
2.	POST-TEST	17.01	2.2	

The table shows the test value of Group B is 6.9 which was greater than the tabulated ‘t’ value 2.145. The result shows that there was marked difference between pre test and post test values.

GRAPH – V

PRE TEST AND POST TEST VALUES OF

ILLINOIS TEST

GROUP B – CORE STABILITY

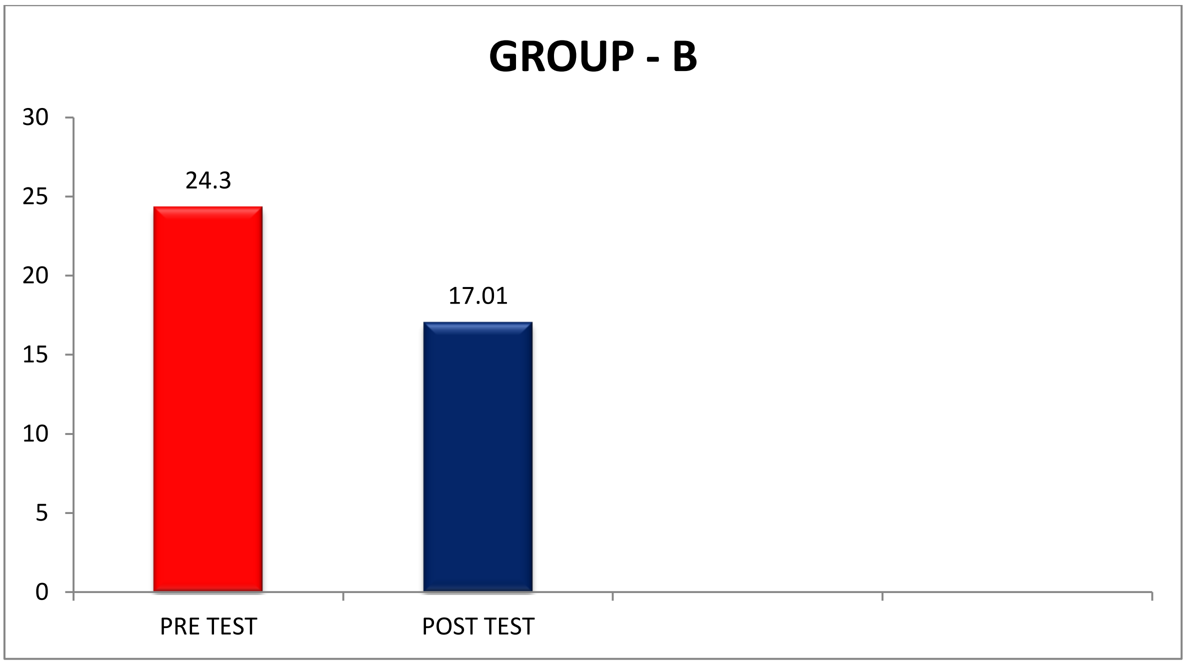


TABLE – VI

POST TEST VALUES OF

ILLINOIS TEST

GROUP A & GROUP B

S.NO	POST TEST	MEAN	STANDARD DEVIATION	't' VALUES
1.	GROUP-A	20.3	2.5	3.8
2.	GROUP-B	17.01	2.2	

The table shows the test value of Group A and Group B is 3.8 which was greater than the tabulated 't' value 2.048. The result shows that there was marked difference between Group A and Group B.

GRAPH – VI

ILLINOIS TEST

GROUP A & GROUP B

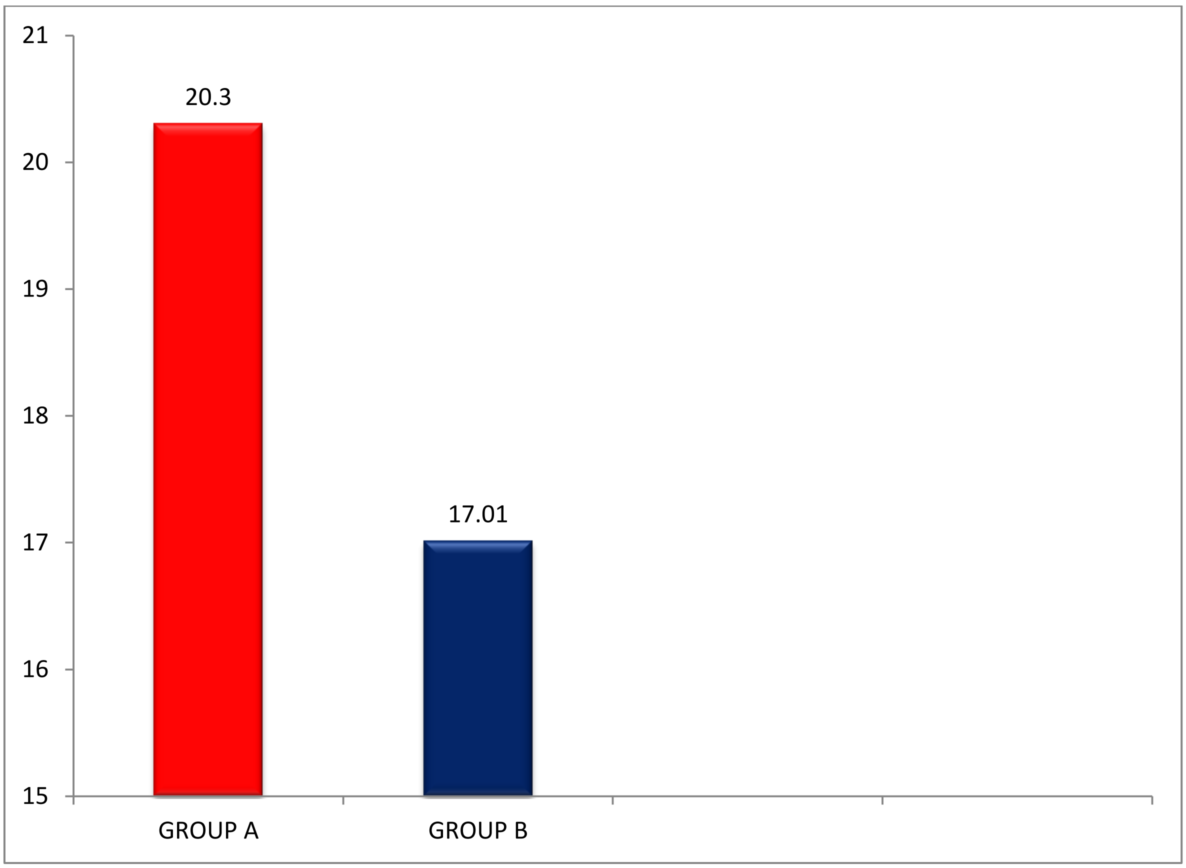


TABLE – VII

PRE TEST AND POST TEST VALUES OF

Y- BALANCE TEST

GROUP A – PLYOMETRIC

S.NO	GROUP - A	MEAN	STANDARD DEVIATION	't' VALUES
1.	PRE-TEST	58.18	5.5	5.81
2.	POST-TEST	59.95	4.9	

The table shows the test value of Group A is 5.81 which was greater than the tabulated 't' value 2.145. The result shows that there was marked difference between pre test and post test values.

GRAPH – VII

PRE TEST AND POST TEST VALUES OF

Y- BALANCE TEST

GROUP A – PLYOMETRIC

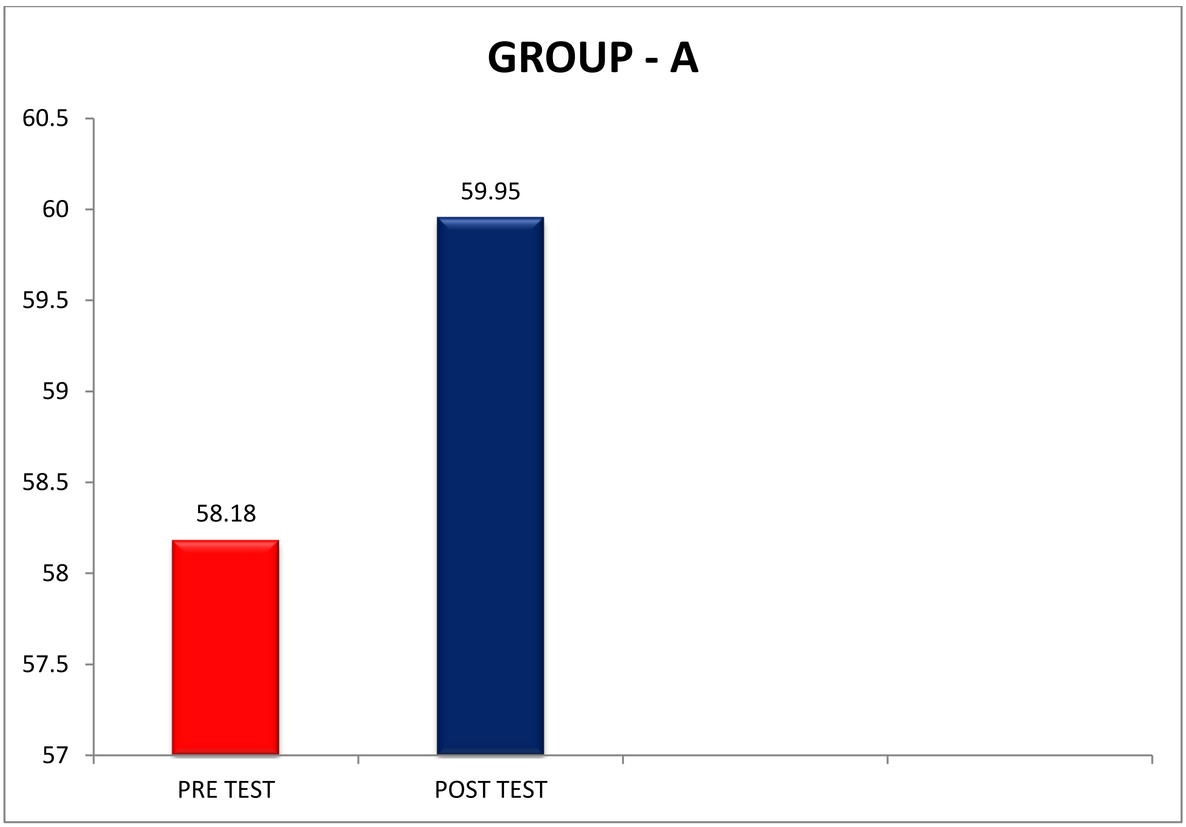


TABLE – VIII

PRE TEST AND POST TEST VALUES OF

Y- BALANCE TEST

GROUP – B- CORE STABILITY

S.NO	GROUP – A	MEAN	STANDARD DEVIATION	't' VALUES
1.	PRE-TEST	59.1	5.14	5.98
2.	POST-TEST	74.4	9.5	

The table shows the test value of Group B is 5.98 which was greater than the tabulated 't' value 2.145. The result shows that there was marked difference between pre test and post test values.

GRAPH – VIII

PRE TEST AND POST TEST VALUES OF

Y- BALANCE TEST

GROUP B- CORE STABILITY

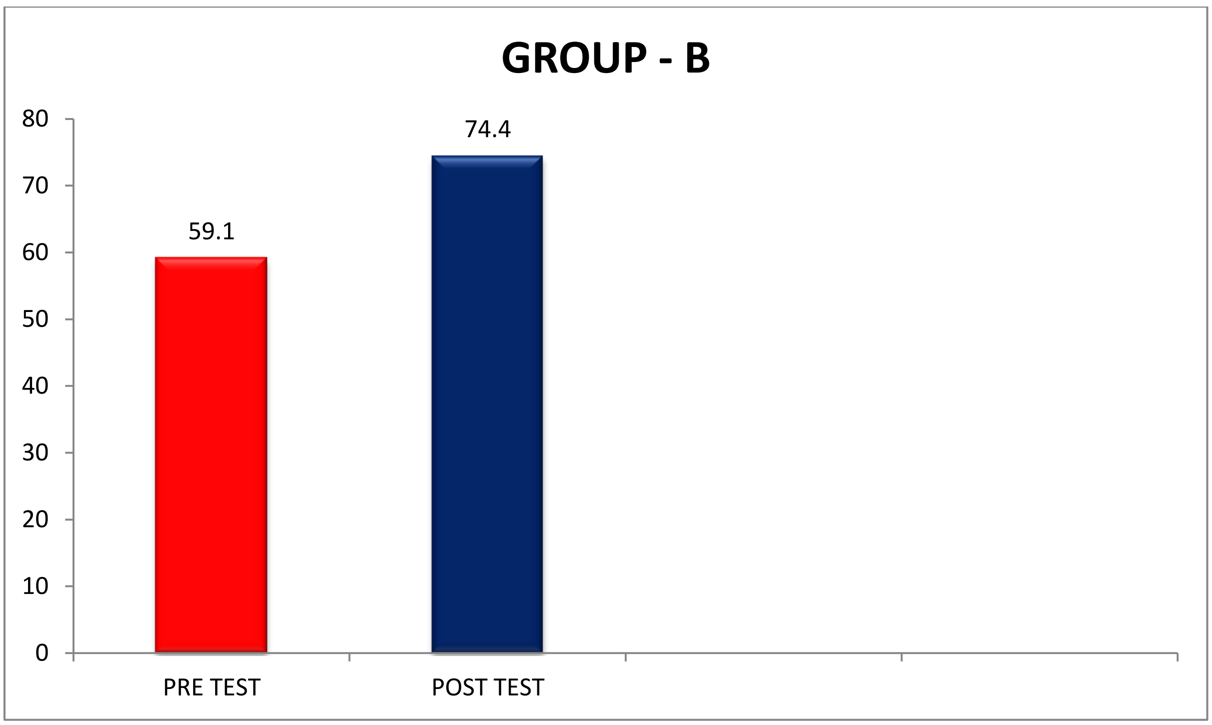


TABLE – IX

POST TESTS OF Y- BALANCE TEST

GROUP A VERSUS GROUP – B

S.NO	POST-TEST	MEAN	STANDARD DEVIATION	‘t’ VALUES
1.	GROUP-A	59.9	4.95	5.22
2.	GROUP-B	74.47	9.55	

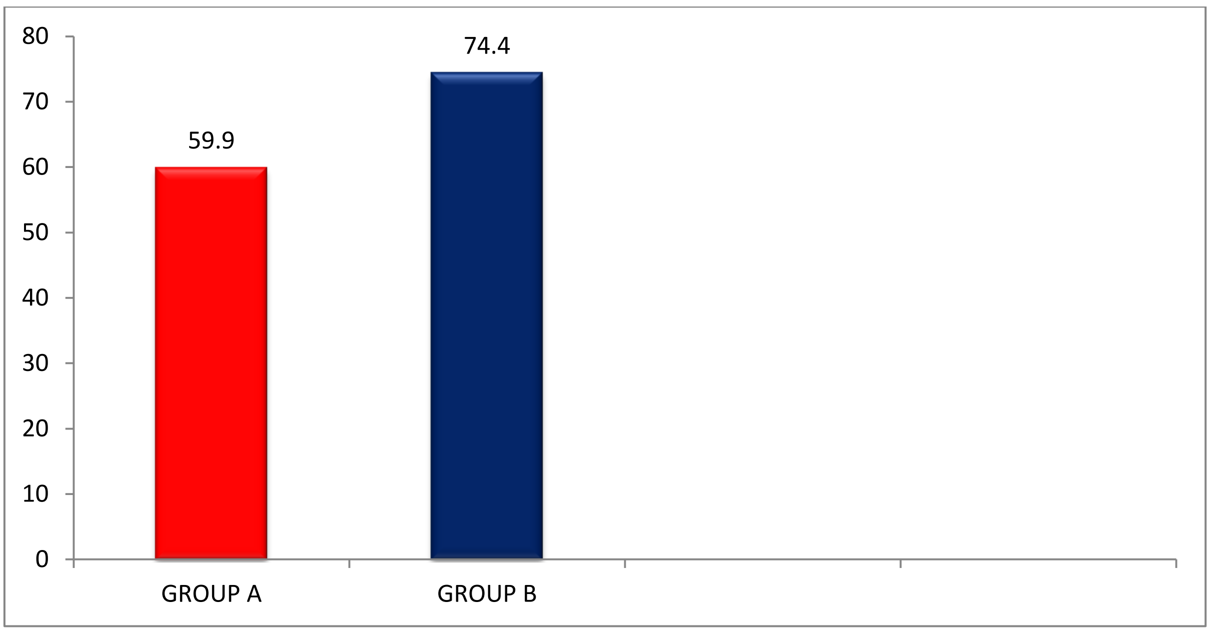
The table shows the test value of Group A versus Group B is 5.22 which was greater than the tabulated ‘t’ value 2.048 . The result shows that there was marked difference between Group A and Group B.

GRAPH – IX

POST TEST VALUES OF

Y- BALANCE TEST

GROUP A & GROUP B



V DISCUSSION

Badminton is one of the most popular sports played all around the world. Badminton players need to be quick and agile around the court. Muscle strength, muscular endurance, power, speed, agility, flexibility, balance and coordination are the important components for a player.

Badminton requires a specific physical conditioning in terms of motor and action controls; coordinative variables such as reaction time, foot stepping and static or dynamic balance, which are essential motor demand in this sport. (M.Phomsoupha et al., 2015)

Agility is one of the important components in badminton. Agility is needed to maintain balance when performing maneuvers quickly and accurately (Vaczi et al.,2011).Balance is the ability to maintain dynamic integration of interior and exterior forces during motor action tasks (E.Bressel et al., 2007)

During performance of sports skills, a stable core provides a foundation upon which the muscle of the upper and lower extremities can accelerate body segments and transfer force between distal and proximal body segments (Samson et al., 2007). Plyometric consists of a rapid stretching of a muscle immediately followed by a concentric or shortening action of the same muscle and connective tissue (Baechle et al., 2000).

The main purpose of the study is to compare the effect of plyometric and core stability on agility and balance in badminton players.

Most of the studies suggest that there is improvement in agility and balance in players who underwent plyometric and core stability training programme. But there are not many studies comparing the effect of both plyometric and core stability training.

A total of about 30 recreational badminton players who fulfilled inclusive and exclusive criteria were selected by simple random sampling method, out of them 15 were allotted in Group A and 15 in Group B.

Prior to the training both the groups underwent warm up and stretching. Group A underwent plyometric whereas Group B underwent core stability exercises. Agility was tested using 10m Shuttle run and Illinois test whereas balance was tested with the use of Y-Balance test both prior to the intervention and after 6weeks of training session.

Statistic analysis was done using SPSS, Paired 't' test was used to find the difference within the group and Unpaired 't' test was used to find the difference between the groups.

Table I shows the paired't' test value of 10meters shuttle run of Group A is 10.19 and Table II shows the paired 't' test value of Group B is 11.02 which was greater than the tabulated ‘t’ value of 2.145. Table III shows the Unpaired‘t’ test value of 10meters shuttle run of Group A and Group B is 4.66 which was greater than the tabulated ‘t’ value 2.048 Which shows that there was significant improvement in Group B when compared to Group A.

Dimas Sondang Irawan et al., 2017 has the same effect in their study and suggest that plyometric movement are components that can help in improving agility because it exploits the adaptation of stretch-shortening cycle through the neuromuscular system in helping to increase leg muscle power so agility improvement can be achieved.

Table IV shows the paired‘t’ test value Illinois test of Group A, is 8.71 and Table V shows the paired ‘t’ test value of Group B is 6.9 which was greater than the tabulated ‘t’ value of 2.145. Table VI shows the unpaired‘t’ test value Illinois test of Group A and Group B is 3.8 which was greater than the tabulated ‘t’ value 2.048 which shows that there was significant improvement in Group B when compared to Group A.

After the training of core stability and plyometric this study demonstrates that core stability has better improvement in agility than plyometric.

Kibler et al 2006 supports this result stating that core stability training integrates activation of multiple segments which provides force generation leads into strong proximal stability and distal mobility.

Higher core stability performance leads to improve synchronization of motor units and lower of neural inhibitory reflexes, so that these training provide better control of the intersegmental motion of the spine. As a result the immediate response of action in lower extremities was improved.

Table VII shows the paired‘t’ test value Y-Balance test of Group A is 5.81 and Table VIII shows the paired ‘t’ test value of Group B is 5.98 which was greater than the tabulated ‘t’ value of 2.145. table IX shows the Unpaired‘t’ test value Y-Balance test of Group A and Group B is 5.22 which was greater than the tabulated ‘t’ value 2.048 Which shows that there was significant improvement in Group B when compared to Group A.

Kibler et al., 2006 suggested that core stability as the control of the position and motion of trunk over the pelvis which allows optimum production of motion over the terminal segment in integrated kinetic chain activities.

Samson et al., 2007 has the same effect in their study and suggest that the core stabilization program emphasizes on the eccentric and isometric muscle actions that are believed to enhance dynamic postural control. A stable core provides a foundation upon which the muscle of upper and lower extremities can accelerate body segments and transfer force between distal and proximal body segments.

While applying core stability exercises the length dependent pattern occurs in the muscle, which increases stability around one joint, and are mediated by gamma afferent input and involve reciprocal inhibition of muscle to provide stiffness around a joint.

Force dependent pattern integrate activation of multiple muscle to move several joints and develop force, and are mediated by Golgi tendon receptors.

With the support of the above study, this study recommends that, individually, the side plank and side raises must be performed with proper form, technique, and endurance, before the athlete is advanced to the combination exercise. The combined exercise is intense and requires coordination of the various core muscle groups on opposite sides of the body. This study has warranted the effects of core exercise on the dynamic balance.

Thus this study concludes that the Group which underwent core stability exercises tends to show significant improvement in agility and balance in recreational badminton players when compared to plyometric group.

VI SUMMARY AND CONCLUSION

The purpose of the study is to find the effect of Plyometric and Core stability exercise and to compare the effect of Plyometric versus Core stability exercise in agility and balance in recreational badminton players. 30 subjects were selected and divided into 2 groups using simple random sampling.

Group A subjects underwent Plyometric whereas Group B underwent Core stability exercise for 6 weeks. Agility was measured using 10m Shuttle Run and Illinois test. Balance was measured using Y-Balance test.

This study rejects the null hypothesis and therefore suggests that core stability improves agility and balance in badminton players than plyometric.

Therefore this can be implemented in treatment protocol for further studies and to prevent injuries.

VII LIMITATION & RECOMMENDATION

LIMITATION:

- Study was done with the use of small sample.
- This study only focuses recreational badminton players.
- This study focuses on two training techniques only
- This study only includes few parameters for intervention.
- Certain factors such as climatic condition, nutritional factors, psychological factors and activities of daily living could not be controlled during the study.

RECOMMENDATION

- Further studies can be conducted:
    - Increasing the sample size
    - Using different training programs combined with plyometric and core stability exercise.
- Similar studies can be performed on other sports also
- Similar studies can be performed in elite athletes
- Further studies can use other outcome parameters for interventions.
- Similar studies can be conducted at various duration of training.

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IX APPENDIX – I

"Plyometric is defined as exercise than enable a muscle to reach maximum strength in a short duration."

"It is a type of exercise training designed to produce fast, powerful movement and improve the function of the nervous system, generally for the purpose of improving performance in a specific sport"

PHYSIOLOGYY OF PLYOMETRIC:

The serial elastic component of muscle, which include the tendons and the cross bridging characteristics of the actin and myosin that make up the muscle fibers.

The sensors in the muscle spindle (propriceptors) that play the role of presetting muscle tension and raying sensory input related to rapid muscle stretching for activation of the "stretch reflex"

The stretch, or myotatic, reflex responds to the rate at which a muscle is stretched and is among the fastest in the human body. The reason for this is that the spinal cord and back of the muscle fiber is responsible for contraction.

The faster a muscle is stretched or lengthened, the greater its concentric force after the stretch. The result is a more forceful movement

Warm up- sub maximal Plyometric drills:

To developed fundamental movement drills and therefore are helping in establishing motor patterns that are going to directly carry over to speed development and jumping ability.

Performed over distance of 10- 20 meters, performing he drills in one direction and

To develop fundamental movement skills and therefore are helpful it establishing motor patterns that are going to directly carry over to speed development and jumping ability

Performed over distance of 10-20 meters, performing the drill in one direction and walk back in the other, allowing recovery as well as mental rehearsal for the next repetition

- Marching drills
- Jogging drills
- Skipping drills
- Footwork drills
- Lunging drills
- Alternate movement drills

Classification of jump:

- Jumps-in-place
- Standing jumps
- Multiple hops and jumps
- Bounding
- Box drills
- Depth jumps

PROTOCOL:

Training	Plyomeric drills	Set* Reps	Intensity
Week 1:			
	Side to side ankle hops : Stand straight with hands by the side and feet hip width apart. Jump with both feet to the right and then to left in a quick repetitive manner.	2 * 15	Low
	Standing jump and reach: Stand with your feet shoulder width apart and your arms at your sides.	2*15	Low

	Bend your knees and sit your hip hips back to squart slightly. Then quickly swing arms up overhead and explode upward by pressing the feet.		
	Front cone hops: Stand in front of a cone with feet shoulder width apart and then jump with both over the cone and then the next.	5*6	Low
Week 2:			Low
	Side to side ankle hops	2*15	Low
	Standing jump: Stand in front of the box and then jump over the box	5*6	Medium
	Lateral jump over barrier: Stand side to the barrier and then jump across with both feets	2*15	Medium
	Double legs hops: Stand with your feet shoulder width	5*6	Medium

	apart and your arms in the front. Bend your knees and sit your hip hips back to squart slightly. Perform short hops in place.		
Week 3			
	Side to side ankle hops	2*12	Low
	Standing jump	5*6	Low
	Lateral jump over barrier	2*12	Medium
	Double legs hops	3*8	Medium
	Lateral cone hops:	2*12	Medium
Week 4:			
	Diagonal cone hops: with 4 cones placed in a square manner each 1meter apart. Start at one corner. Landing with leading foot hop to the cone at your side. Hop diagonally to the next cone. Hop to the remaining cone to complete the circuit	4*8	Low

	Standing long with lateral sprint	4*7	Low
	Lateral cone hops	2*12	Medium
	Single leg bounding	4*7	High
	Lateral jump single leg: Stand shoulder width apart. Jump up but push sideways to the left off the ground and land on your left foot. Immediately push off to the right side and repeat it.	4*6	High
Week 5:			
	Diagonal cone hops	2*7	Low
	Standing long with lateral sprint	4*7	Medium
	Lateral cone hops	4*7	Medium
	Cone hops with 180degree turn: stand facing forward, parallel to the cones. Jump, while in air turn 180 so that you land facing the opposite direction and continues till the circuit gets over.	4*7	Medium

	Single leg bounding	4*7	High
Week 6:	Lateral jump single leg	2*7	High
	Diagonal cone hops	2*12	Low
	Hexagonal drill: Stand in the center of the hexagon with feet shoulder width apart. Jump across one side of hexagon and back to the center then proceed to other sides.	2*12	Low
	Cone hops with change of direction sprint	4*6	Medium
	Double leg hops	3*8	Medium
	Lateral jump single leg	4*6	High

APPENDIX – II

CORE STABILITY EXERCISE

Core strength training is gradually recognized and a very important and special strength training. Core strength training has gradually become popular sport training.

Core strength training is a kind of physical training, it uses a variety of related training equipment and training method of the core area of the muscle groups to carry out targeted training, improve the human core function to the human body center of gravity wave motion stability.

CHARACTERISTICS OF THE CORE STRENGTH:

Core strength is a kind of strength training ability which is the main function of stabilizing the core part of the human body, controlling the movement of the upper and lower limb. Compared with general strength, core strength is more prominent on muscle innervations and control, more emphasis on the development of small muscles and the cooperation between big muscles and small muscles.

Role of strength training in badminton:

- To enhance the stability of the spine and pelvis in the sport

- To improve the energy output of athletes
- To enhance the coordination of the work of the body
- Prevent sport injuries.

Core strengthening exercises concentrated mainly on transverse abdominus (TrA) and multifidus (MF) muscles.

TRAINING	**CORE STRENGTHENING EXERCISE**	**SETS*REPS**
Week 1 & 2:		
6.	**TrA& MF muscle contraction:**	
	Crook supine lying position : In which the subject is asked to flex both the knees to the maximum, feet flat on the ground and with arms on the head slow sit-up exercise in supine lying.	3*15
	Prone lying position: The subject is asked to lie on the stomach and contract the abdomen	3*15
	Quadruped position: In prone position the subject maintains a straight spine and progress to flex the hip knee, elbow and hand and	3*15

	contract the abdomen.	
	Standing on single limb: Patient is made to stand and bear the body weight on single leg.	1*10
	Crook lying with leg movements: from crook lying the subject is asked to lift leg alternatively.	2*10
7.	**Bridging:** Subject is made to lie supine with hands beside and asked to flex knee and lift the pelvis up.	3*15
8.	**Quadruped exercise with foot and hand lifts:** From quadruped position the subject is asked to lift alternate leg and hand at the same time.	3*15
9.	**Wall squarts :** Subject is made to stand near the wall, supported with both the hands lifted and made to do squats by sliding parallel to the wall	3*15
10.	**Seated medicine ball rotation:** Subject is made to sit over an unstable ball and rotate the ball side to side to regain balance.	3*15

Week 3 & 4		
1.	**TrA& MF contraction:**	
	Cycling: Subject is made to lie supine and flex the hip and knee in an alternate manner as if cycling.	3 *15
	Seated on swiss ball: Subject is asked to contract the abdomen while sitting on the swiss ball by grasping the ball with the lower limb.	3 *15
	Multidirectional lunges: The subject is asked to positioning one leg over the ball with a flexed knee while the other leg is placed on the ground a width apart and asked to move forward.	2*10
2.	**Squarts with swiss ball:** Subject is asked to place the ball behind the back with wall support and asked to squart.	3 *15
3.	**Superman :** In bridging position the subject is asked to alternately lift one leg and hand and maintain the position and then the other side	2*10

Week 5		
Planks 1.	**Modified planks:** Subject is asked to knee downand adopt a prone position with hands placed on the ground and then made to maintain a straight spine and hold the position without flexing the hip.	3 *10
2.	**Front planks:** Subject is made to lie prone with elbows close to your sides and directly under the shoulder, palms down and hands facing forward. Contract the legs to extend and ankle to dorsiflexContract abdomen to maintain torso.	3*10
3.	**Side planks:** Subject is asked to raise from side lying with the support of arm and elbow and then asked to maintain the position.	3*10
4.	**TrA& MF contraction :**	
	Diagonal curls on swiss ball: Subject is asked to lie supine on the ground and place	3 *15

	both the legs on the swiss ball and then alternatively place the head behind the head and touch the knee with the elbow.	
	Twist on swiss ball : Subject is made to place both the foot over the ball and then rotate the ball from side to side.	3*15
Week 6:		
Stability ball:	**Front Planks**	2*10
	Back bridge	2*10
	Theraband resisted shoulder movements seated: The subject is asked to perform shoulder exercises – flex, extension and abduction and adduction with theraband in hand	3*15
	Prone hip-knee flex – extension: The subject is made to extend the hip and knee from prone lying on the ball.	2*10
	Twist on swiss ball with 1 Kg medicine ball: With the subject seated on the balance ball with 1Kg	10 reps

	medicine ball in hand the subject is asked to turn from side to side.	
	Stability trainer standing twists with 1 Kg medicine ball: The subject is asked to stand erect with medicine ball in hand and asked to turn from side to side.	3*15

APPENDIX – III

10 METERS AGILITY SHUTTLE RUN

This test measures agility and speed while running between two line 10m apart to pick up a small block.

PURPOSE:

Thisis used to test speed, body control and the ability to change direction.

EQUIPMENT REQUIRED: two wodden blocks for each runner, marker cones or marking tapes, measuring tape, stopwatch, non-slip surface, with two lines 10 meters apart.

PRE-TEST: test procedure was explained to the subject. Perform screening for health risks and obtain informed consent. Prepare form and record basic information such as age, height, gender, test conditions. Measure and mark out the course. Ensure that the subjects are adequately warmed up.

PROCEDURE:

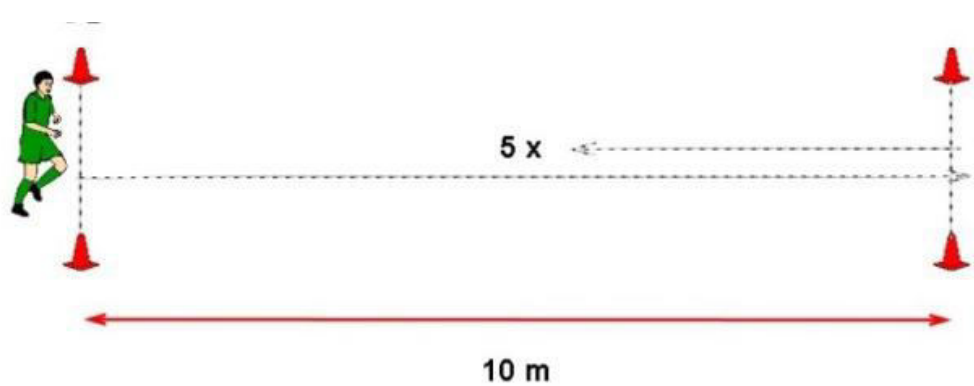
Mark two line 10 meters apart using marking tape or cones. The two blocks are placed on the line opposite the line they are going to start at. On the signal “ready”, the participant sprints to the opposite line, picks up a block of wood, runs back and places it on or beyond the starting line. Then turning without a rest, they run back to retrieve the second block and carry it back across the finish line. Two trial are performed.

SCORING:record the time to complete the test in seconds to the nearest one decimal place. The score is the better of the two times recorded. A trial is void if a block is dropped or thrown.

TARGET POPULATION: This test is used to find out the agility in sports which include agility as the main component. Eg: tennis, soccer, badminton and basketball

ADVANTAGES: this test can be conducted on large group relatively quickly with minimal equipment required.

The blocks should be placed not thrown across. The participants should run through the finish to maximize his speed score. The running speed, turning technique and coordination are also significant factors in this test.



APPENDIX – IV

ILLINOIS AGILITY TEST

Illinois agility test is a commonly used test of agility in sports.

PURPOSE: to test running agility

EQUIPMENT REQUIRED: flat non- slip surface, marking cones, stopwatch, measuring tape.

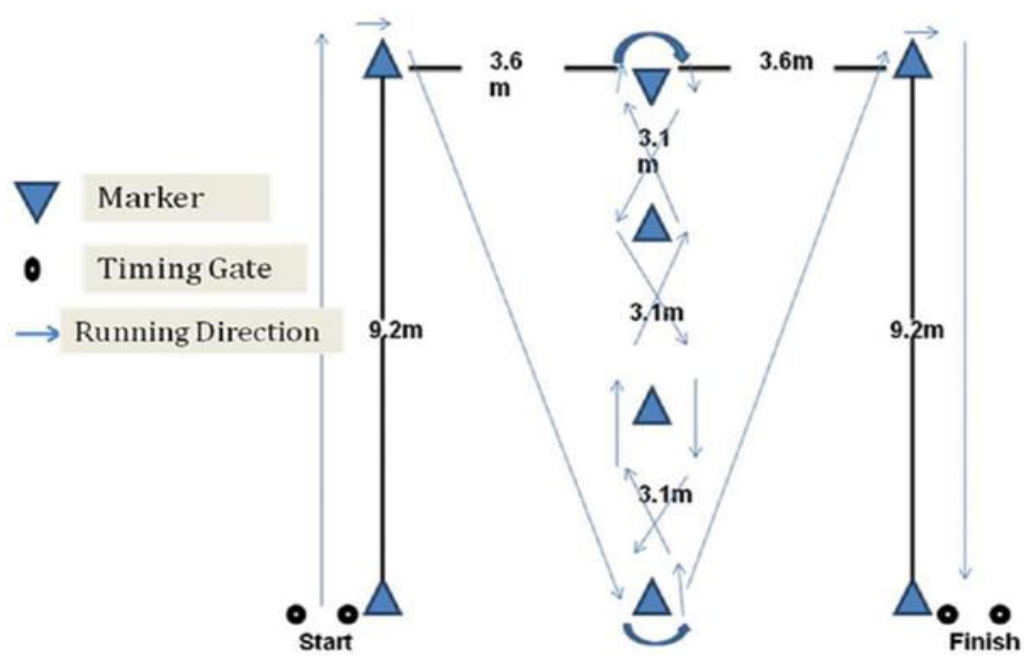
PRE-TEST: test procedure was explained to the subject. Perform screening for health risks and obtain informed consent. Prepare form and record basic information such as age, height, gender, test conditions. Measure and mark out the course. Ensure that the subjects are adequately warmed up.

PROCEDURE: the length of the course is 10meters and the width is 5meters. Four cones are used to mark the start, finish and the two turning points. Another four cones are placed down the center an equal distance apart. Each cone in the center is spaced 3.3 meters apart. Subjects should lie on their front and hands by their shoulder. On the “go” command the stopwatch is started and the athlete gets up as quickly as possible and runs around the course in the direction indicated, without knocking the cones over, to finish line at which the timing is stopped.

RESULT: an excellent score is under 15.2 seconds for a male, less than 17 seconds for a female.

ADVANTAGES: this is a simple test to administer, requiring little equipment. Also, the player ability to turn in different direction and different angles is tested.

DISADVANTAGES: choice of footwear and surface area can affect time greatly. Result can be subject to timing inconsistencies, which may be overcome by using timing gates and cannot distinguish between right and left turn.



APPENDIX – V

Y- BALANCE TEST

Y-Balance test is a dynamic test performed in a single-leg stance that requires strength, flexibility, core control and proprioception. It has been used to assess physical performance, demonstrate functional symmetry and identify athletes at greater risk for lower extremity injury.

PURPOSE: to assess active balance and core control

EQUIPMENT REQUIRED: Y-Balance test marking, measuring tape

PRE-TEST: test procedure was explained to the subject. Perform screening for health risks and obtain informed consent. Prepare form and record basic information such as age, height, gender, test conditions. Measure and mark out the course. Ensure that the subject are adequately warmed up.

PROTOCOL:

The goal of this test is to maintain single-leg balance on one leg while reaching as far as possible with the contralateral leg in three different direction. The three movement directions are anterior, posteromedial and postero lateral which is performed on the dominant leg.

PROCEDURE:

The starting position is standing on one leg at the stance plate with the toes of the foot at the red line and the other leg touching down lightly.the non-stance foot is reached out in the desired direction, placing the foot on the tape marked on the ground and then the distance is measure and noted down.

SCORING:

All measurements are taken from the tape on the different directions. The distance can be read from the marking done. Each test is repeated three times, and the maximum reach in each direction is recorded. The results are calculated taking limb length into consideration, to determine a "Absolute reach distance".

Formula:

$$\text{Absolute reach distance} = \frac{\text{reach 1 + reach 2+ reach 3}}{3}$$

APPENDIX – VI

CONSENT FORM

This is to certify that I ______________ freely and voluntarily agree to participate in the study **"EFFECTS OF PLYOMETRIC AND CORE STABILITY EXERCISE ON PHYSICAL PERFORMANCE OF BADMINTON PLAYERS" - A COMPARATIVE STUDY**

I have been explained about the procedures and the risks that would occur during the study.

Signature of the Participant:

Signature of the Witness:

Date:

I have explained and defined the procedure to which the subject has consented to participate.

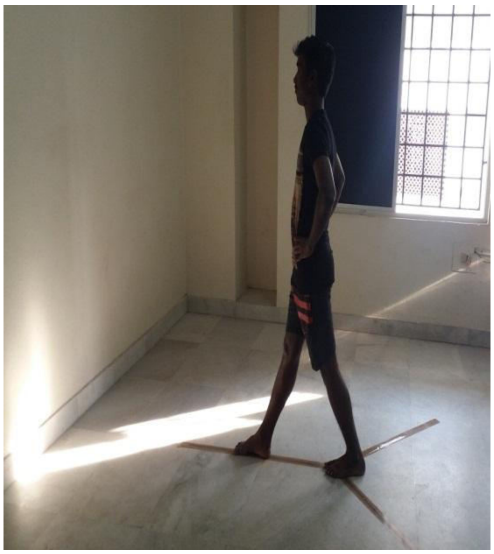
Signature of the Researcher:

Date:

ILLINOIS AGILITY TEST

Y- BALANCE TEST

Anterior reach



Posteromedial reach

Posterolateral